

Mars Science Laboratory Investigations in Holden Crater

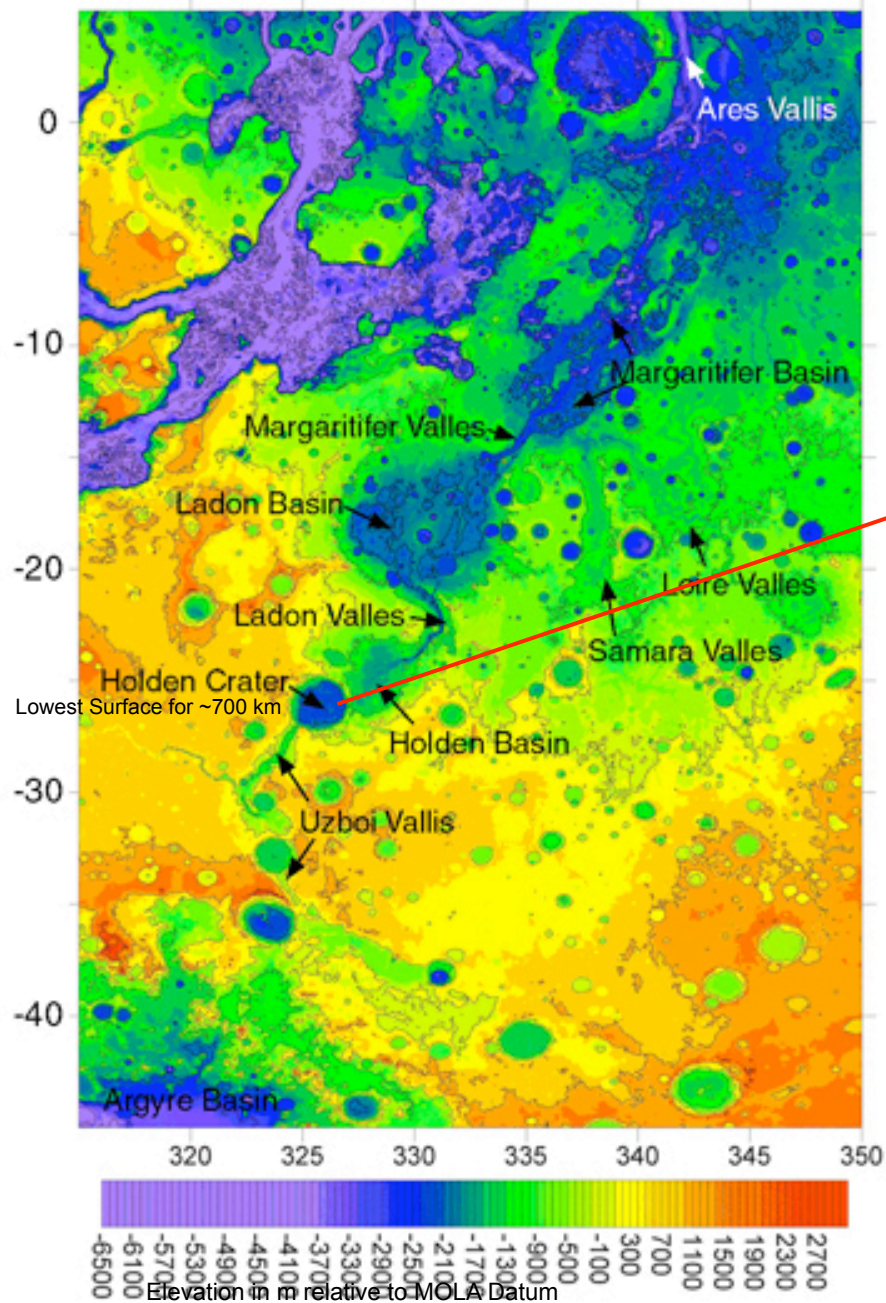
John Grant, Ross Irwin, John Grotzinger, Ralph Milliken, Kelin Whipple, Livio Tornabene, Alfred McEwen, Cathy Weitz, Steve Squyres, Tim Glotch, Brad Thomson, James W. Rice, M. C. Malin, K. E. Edgett

100 m

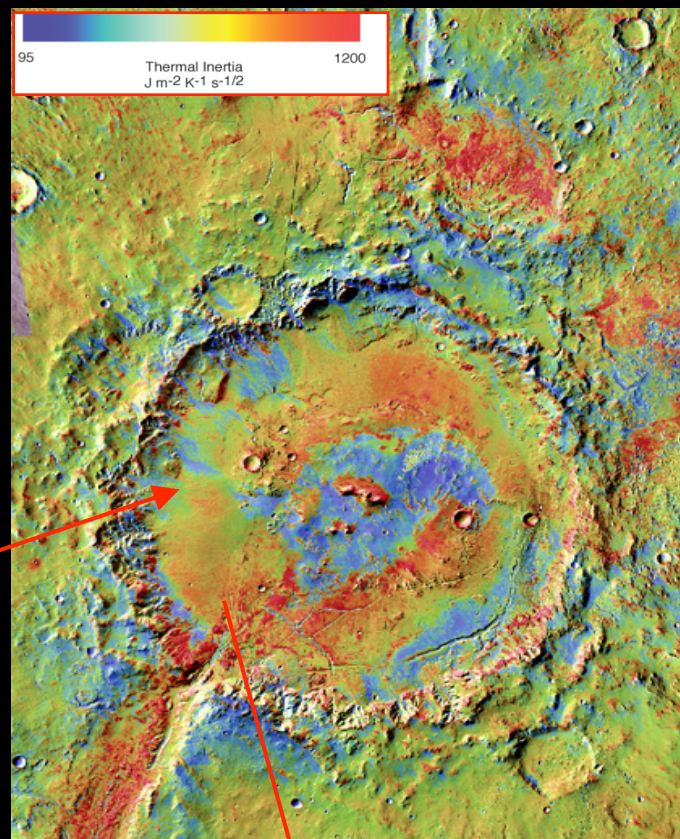
PSP_002721_1530_IRB

MOLA Topography of ULM System

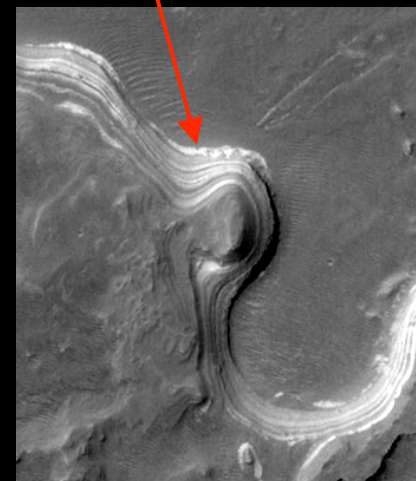
Contour Interval is 1.0 Km



TI over THEMIS Daytime Mosaic (from ASU)



Holden Crater is ~154 Km in Diameter



MSSS MOC

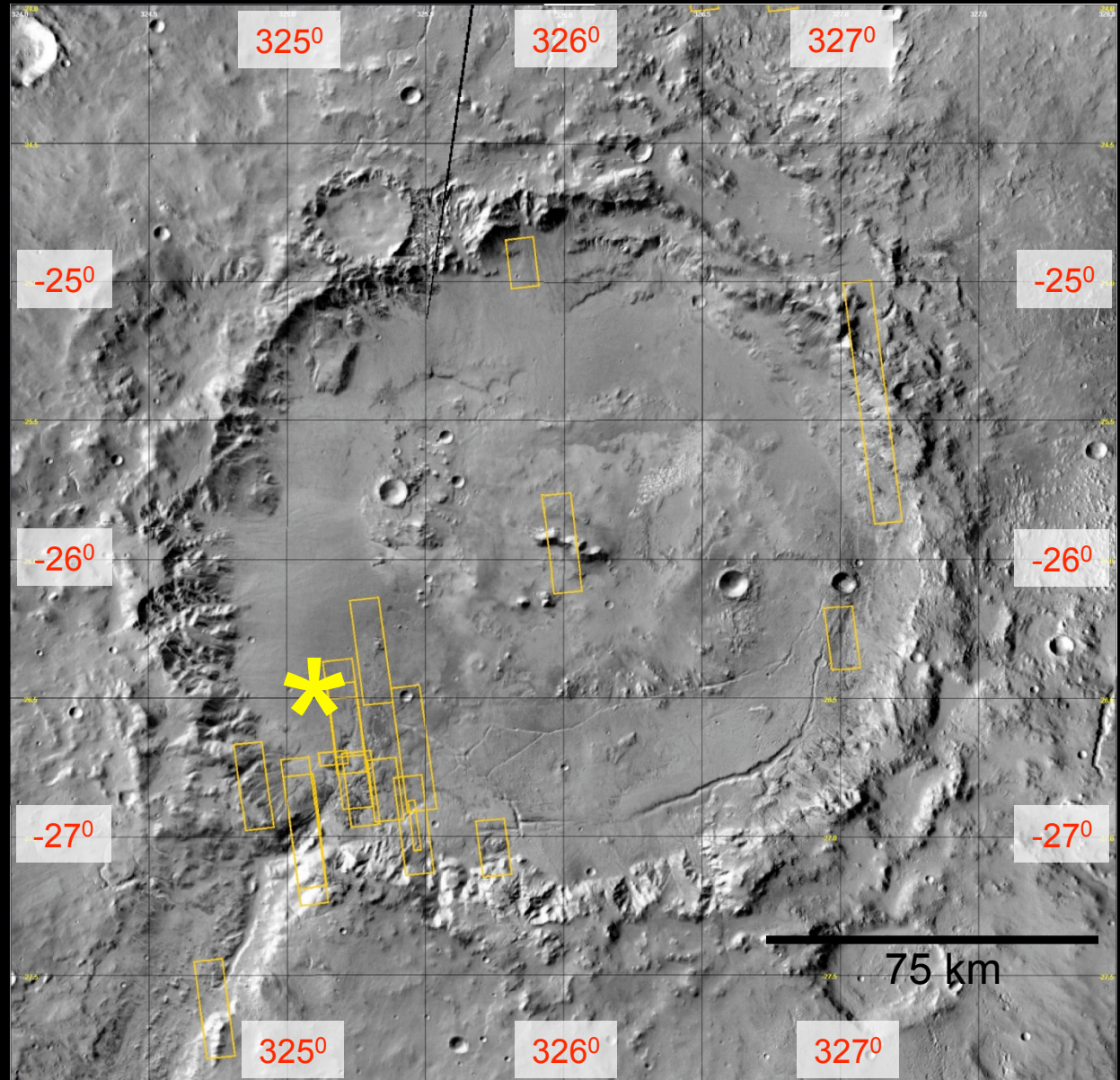
Context:

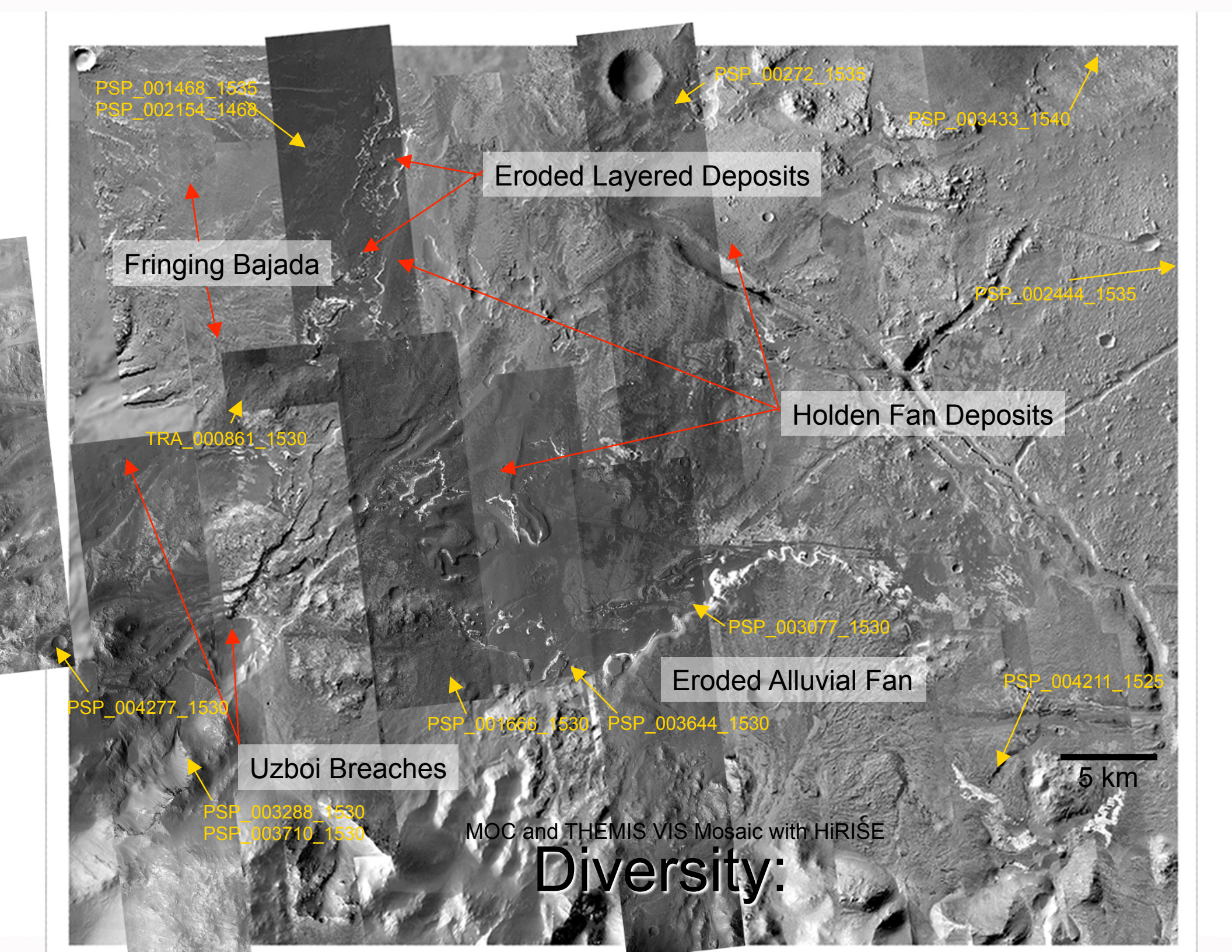
- Holden Crater is 154 km in diameter, Noachian in Age:
 - Impacted, Excavated Sediments in Ancient Holden Basin
 - Interrupted Uzboi-Ladon-Morava Valles (ULM)
 - Crater Floor Mantled by Layered and Fan Deposits
 - Well Mapped by Pondrelli et al. 2005
- Uzboi Vallis Breached Holden Rim in late Noachian:
 - Noachian-Aged Nirgal Vallis Enters/Incises Mid-Uzboi
 - Uzboi Overflow Created Multiple Rim Breaches.
 - Discharge Eroded Pre-Existing Deposits, Emplaced Fans/Layers
 - Holden deposits may not be unique, just uniquely exposed
- Deposits attributed to water, ice, and wind, alluvial/lacustrine:
 - Example References: Grant et al. 2008, Pondrelli et al. 2005, Moore and Howard 2005, Irwin et al. 2005, Grant and Parker 2002, Malin and Edgett 2000, Parker 1985
 - Recent work suggests stratigraphy reflect distal alluvial/lacustrine setting
- Kelin Whipple will discuss science on alluvial fans, Ross Irwin will discuss notional traverses, and Ralph Milliken will discuss mineralogic data and interpretations

HiRISE Image Footprints in Holden:

HiRISE Images Enable:

- Mapping Detailed Stratigraphy
- Defining Stratigraphic Relationships
- Compare SW to Central Peak and East Basin





PSP_001468_1535
PSP_002154_1468

PSP_00272_1535

PSP_003433_1540

Eroded Layered Deposits

Fringing Bajada

PSP_002444_1535

TRA_000861_1530

Holden Fan Deposits

PSP_003077_1530

Eroded Alluvial Fan

PSP_004211_1525

PSP_004277_1530

PSP_001666_1530

PSP_003644_1530

Uzboi Breaches

PSP_003288_1530
PSP_003710_1530

5 km

MOC and THEMIS VIS Mosaic with HiRISE

Diversity:

Basement: Mega-Breccia

Location of Next Slide

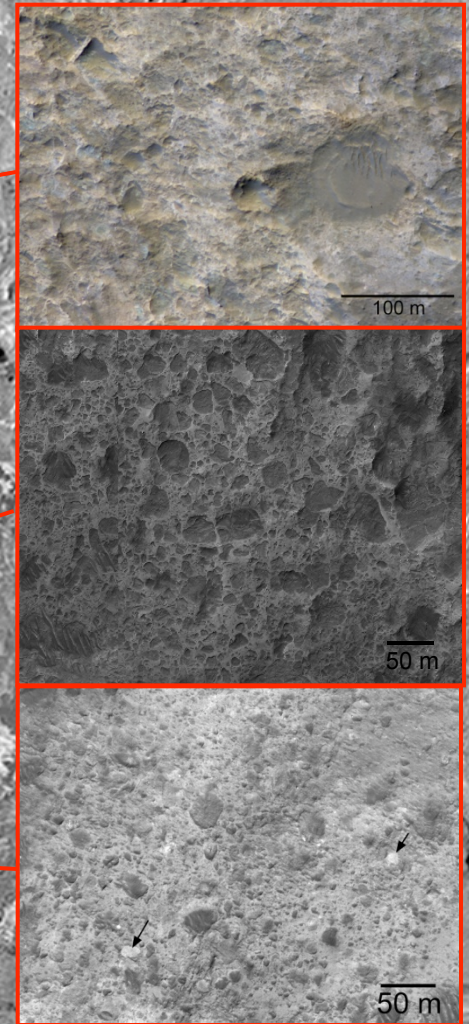
MB

MB

Popigai – from Livio Tornabene

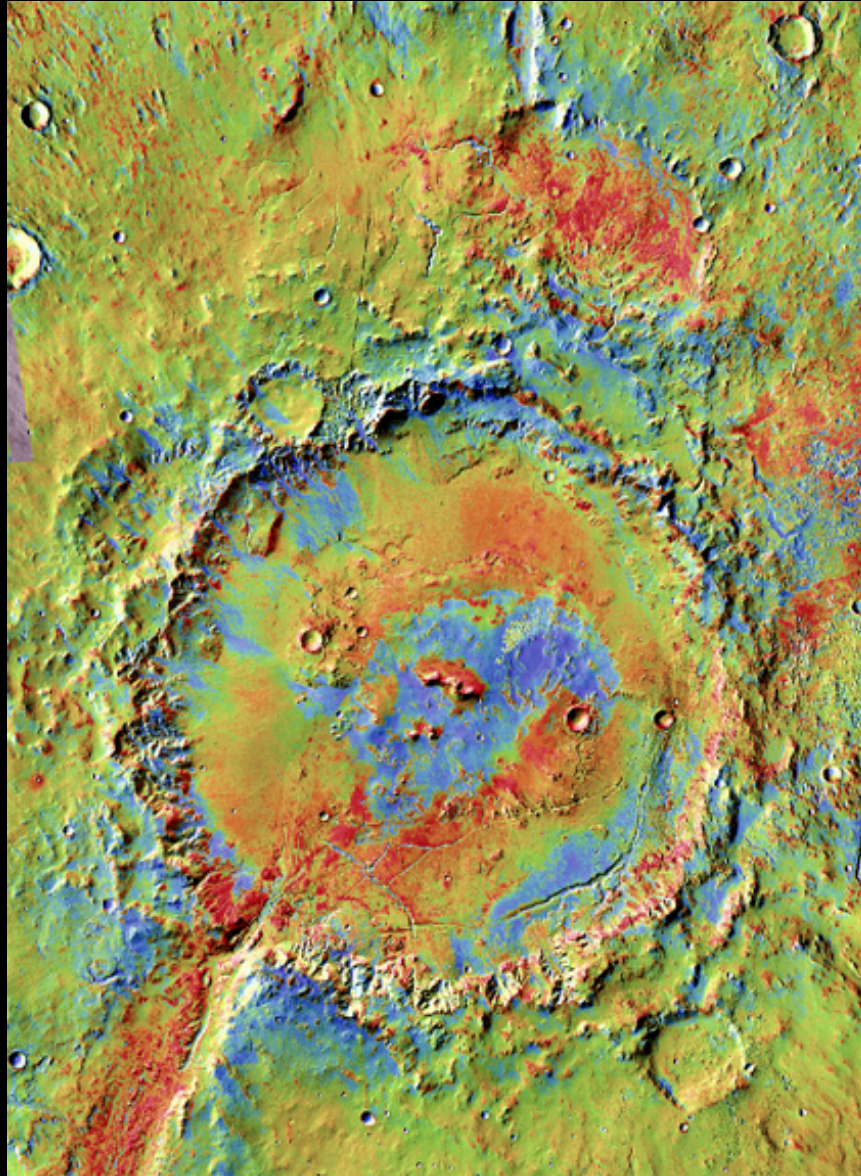


- Observed in Crater Walls
- Occur as Distinct “Clasts”
- Some Stand in Positive Relief
- Diverse, Some Light Toned Clasts
- Locally Associated with “Veins”
- Blocks of Holden Basin Sed Fill?
- Fall Back or Late Collapse of Walls
- Observed in Many Craters



5 km

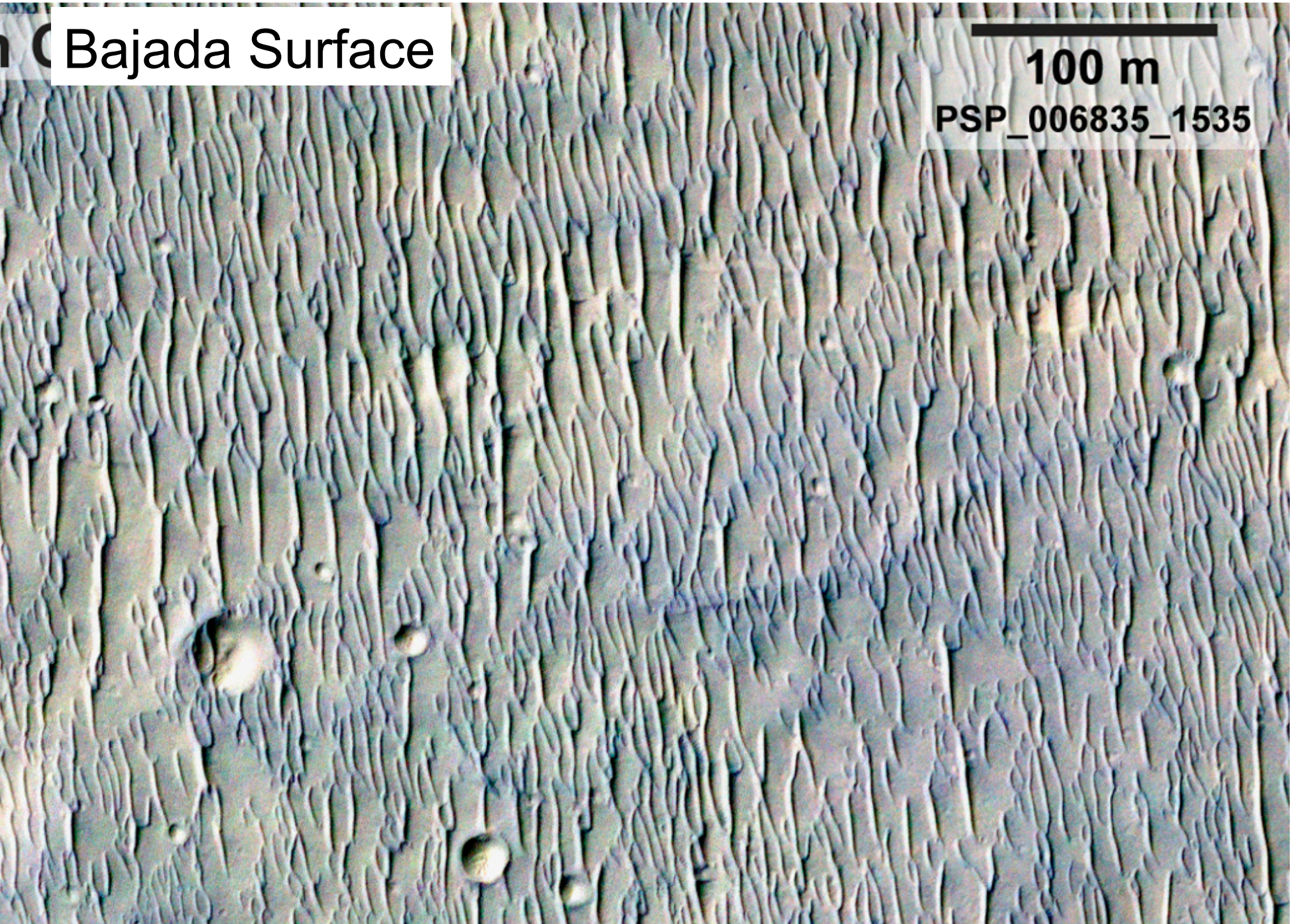
Ancient Aqueous Settings: Morphologic and Mineralogic Evidence



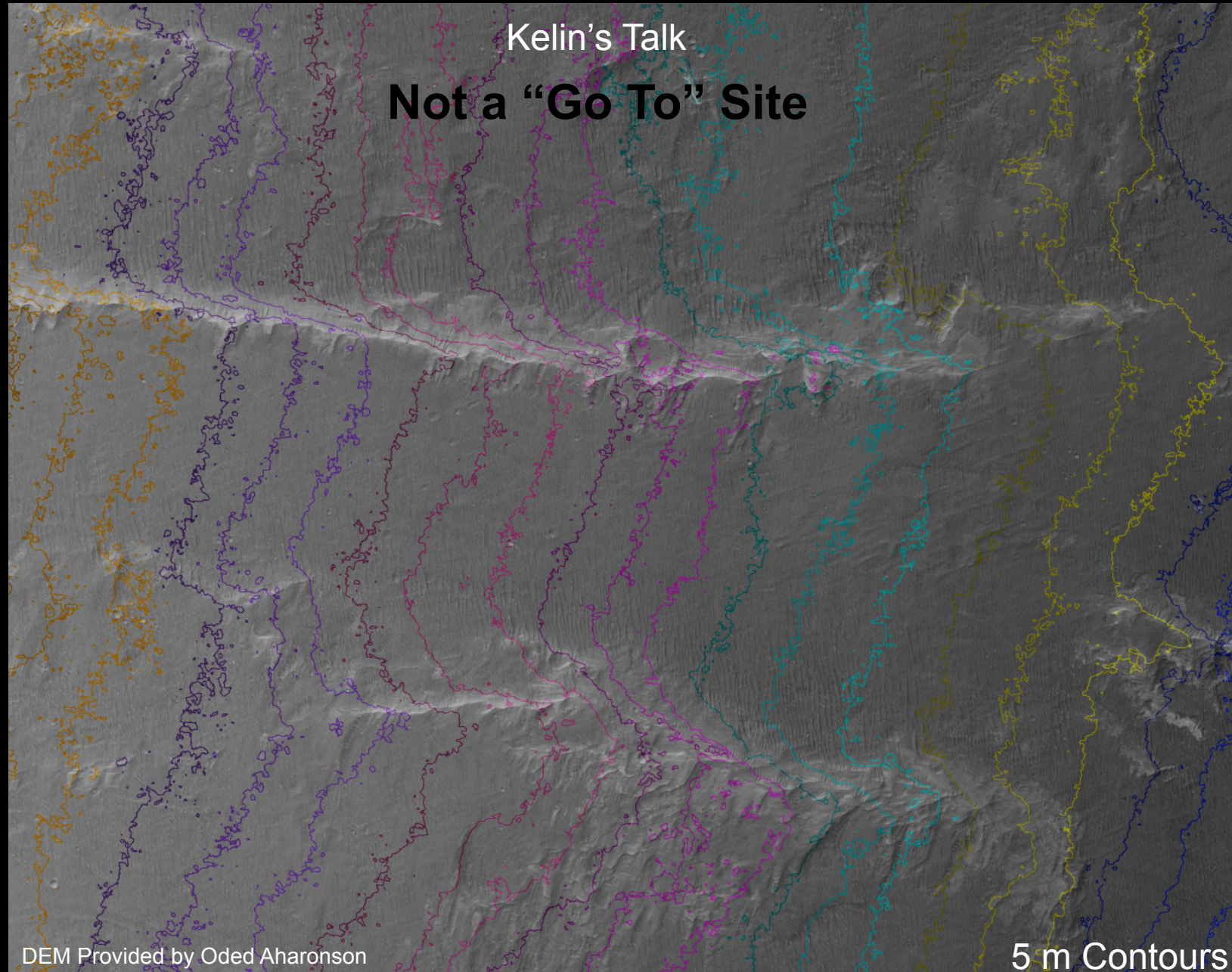
Bajada Surface

100 m

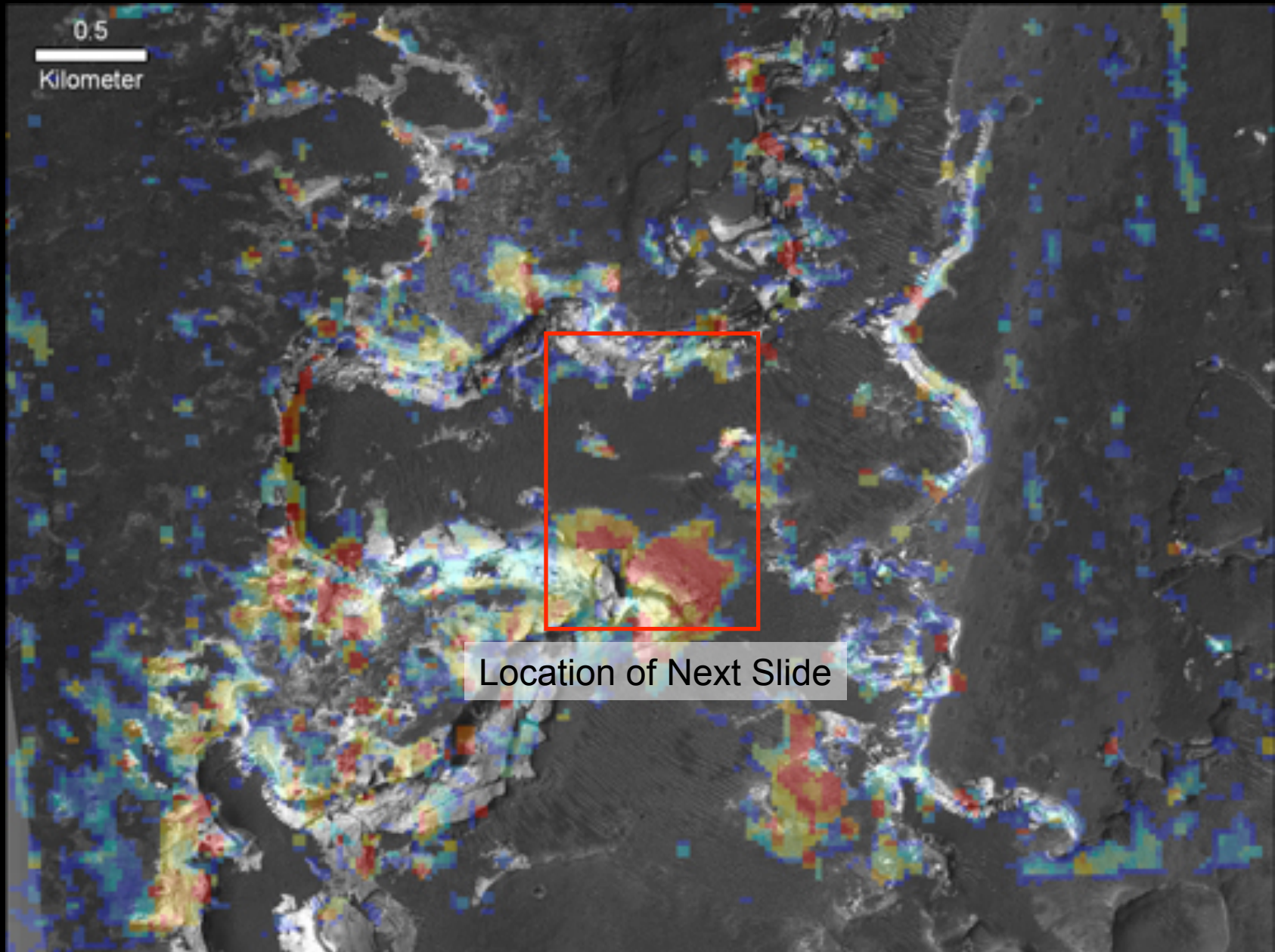
PSP_006835_1535



Science and Relief on the Bajada Surface:



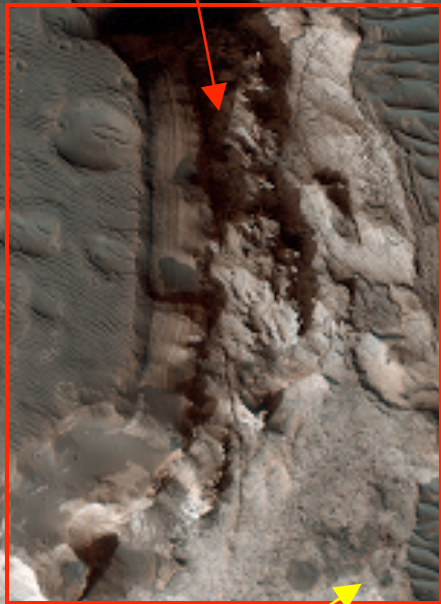
A Nod to the Phyllosilicates (see Ralph's Talk):



Lower Unit Stratigraphy Exposed in Holden Crater:

Traverses to get to these: Ross' Talk

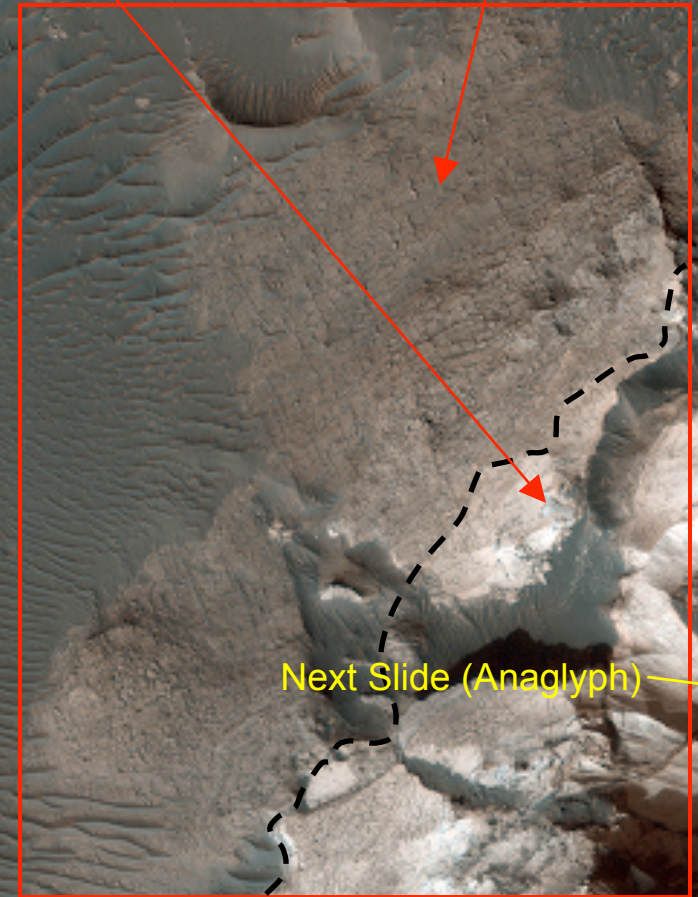
Middle/Upper Members



Slide After Next



Middle and Lower Members

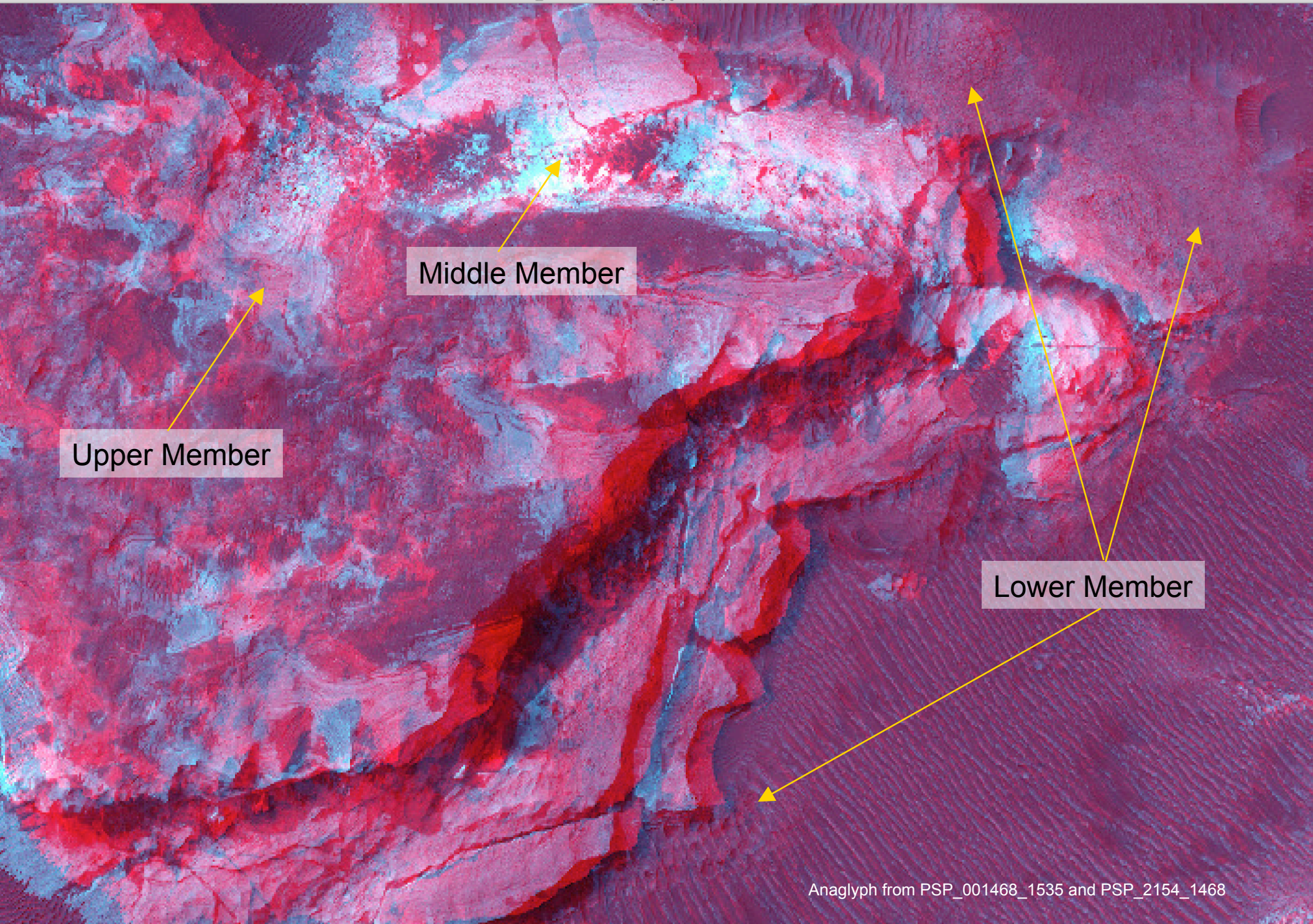


Next Slide (Anaglyph)



500 m

PSP_001468_1535_RGB



Middle Member

Upper Member

Lower Member

Anaglyph from PSP_001468_1535 and PSP_2154_1468

Middle/Upper Lower Unit Section:

HiRISE Image PSP_001468_1535_IRB and RED (inset)
Resolutions 28 to 56 cm/pixel

100 m

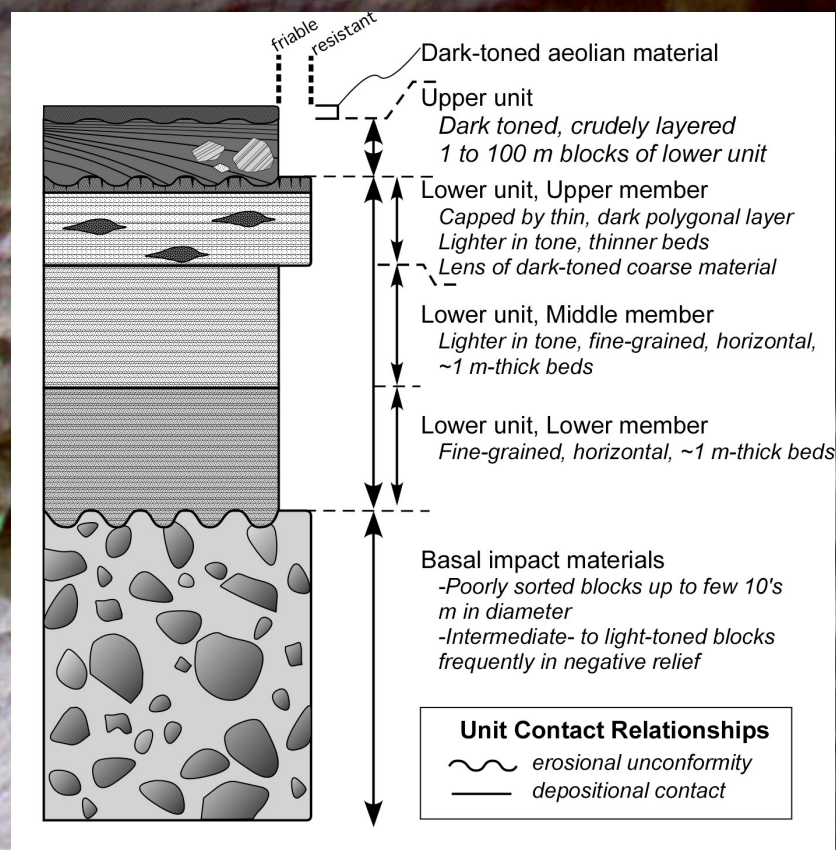
Eolian Sediments

Upper Unit

Lower Unit – Upper
Mg/Fe Phyllosilicates*

Lower Unit – Middle
Mg/Fe Phyllosilicates*

*Based on CRISM Data



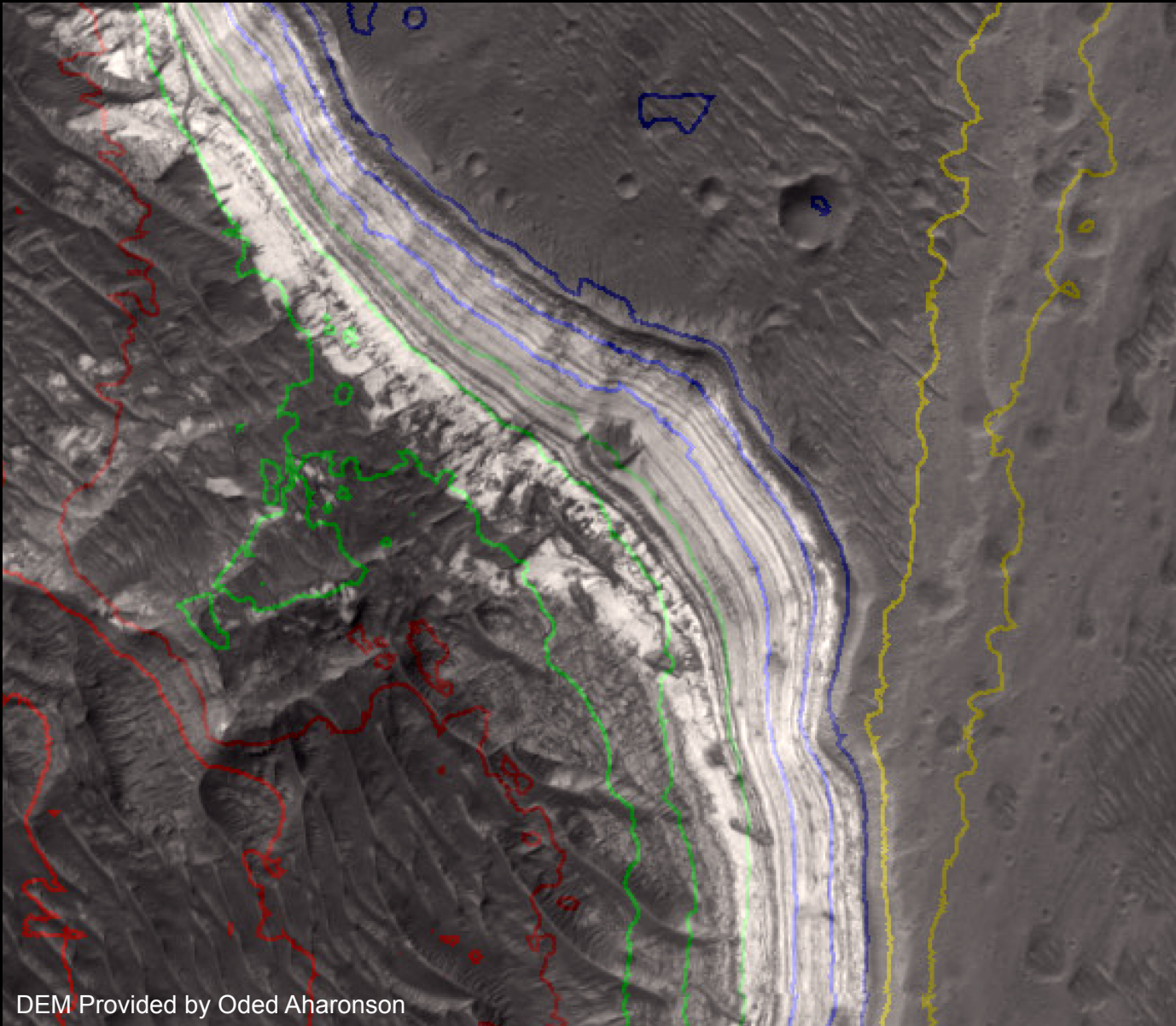
Distal Alluvial vs. Lacustrine:

DEM Provided by Oded Aharonson

Next Slide

Elevation: Color
-2055m: White
-2060m: Black
-2065m: Thistle2 (dark)
-2070m: Thistle1 (light)
-2080m: Sienna2
-2085m: Sienna1
-2090m: Orange4
-2095m: Orange3
-2100m: Orange2
-2105m: Orange1
-2110m: Purple3
-2115m: Purple2
-2120m: Purple1
-2125m: Maroon3
-2130m: Maroon2
-2135m: Maroon1
-2140m: Magenta3
-2145m: Magenta2
-2150m: Magenta1
-2155m: Cyan3
-2160m: Cyan2
-2165m: Cyan1
-2170m: Yellow3
-2175m: Yellow2
-2180m: Yellow1
-2185m: Blue3
-2190m: Blue2
-2195m: Blue1
-2200m: Green3
-2205m: Green2
-2210m: Green1
-2215m: Red3
-2220m: Red2
-2225m: Red1
-2230m: Thistle
-2235m: Chartreuse
-2240m: Sienna
-2245m: Orchid
-2250m: Aquamarine
-2255m: Coral
-2260m: Purple
-2265m: Sea Green

Distal Alluvial vs. Lacustrine:



DEM Provided by Oded Aharonson

Few Obvious
Truncations.
But....

Flat-Lying?

- not quite

Draped?

Dipping?

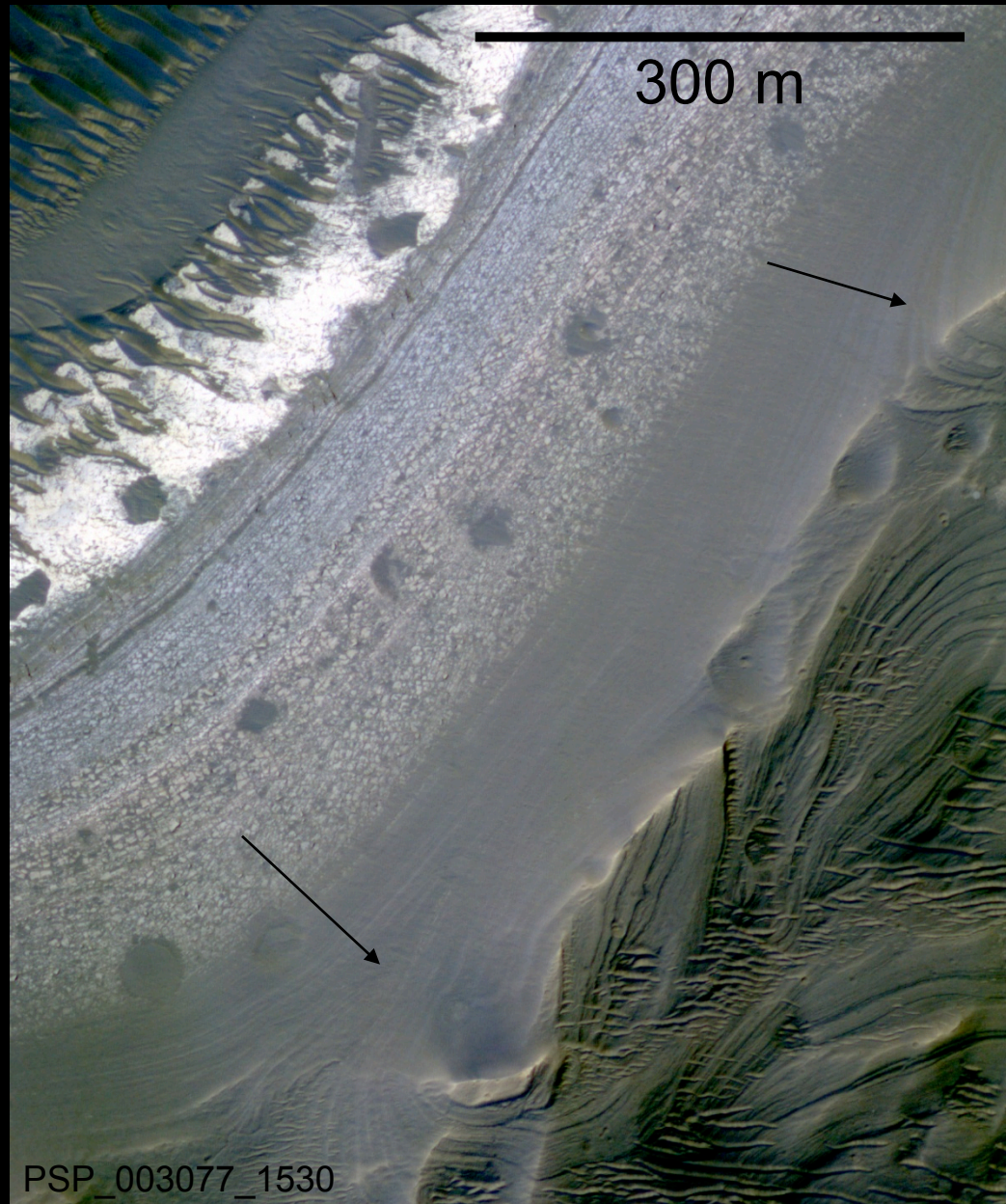
Deformed?

- Structure to
SE

Beds continuous
and constant
Thickness

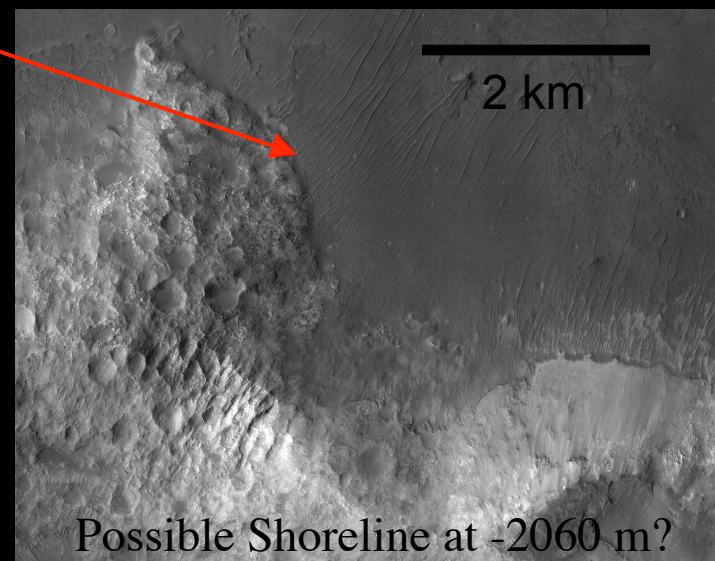
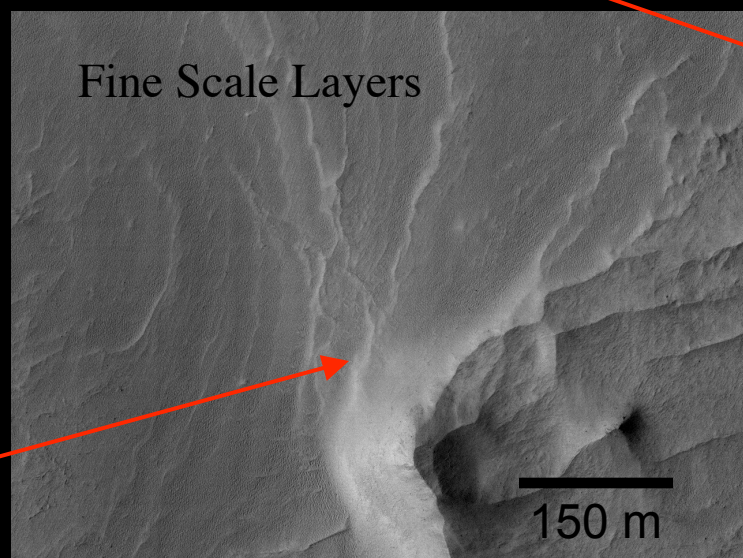
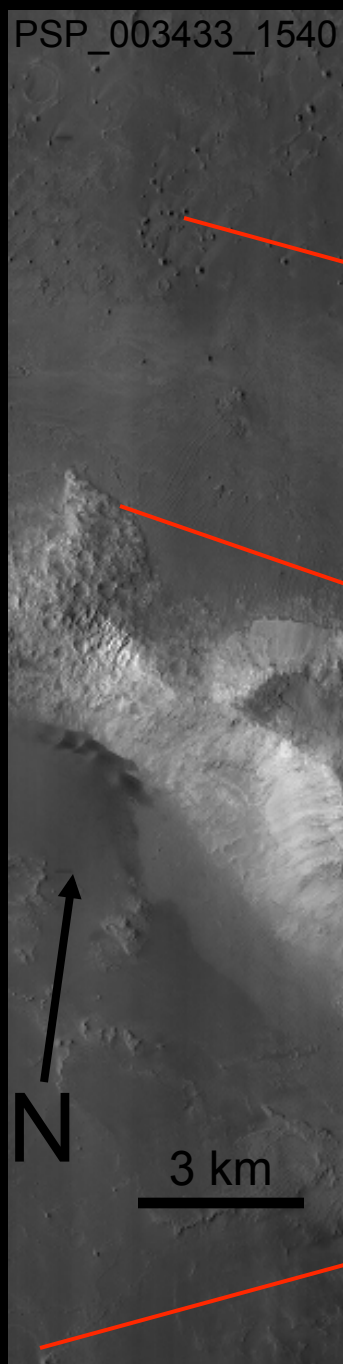
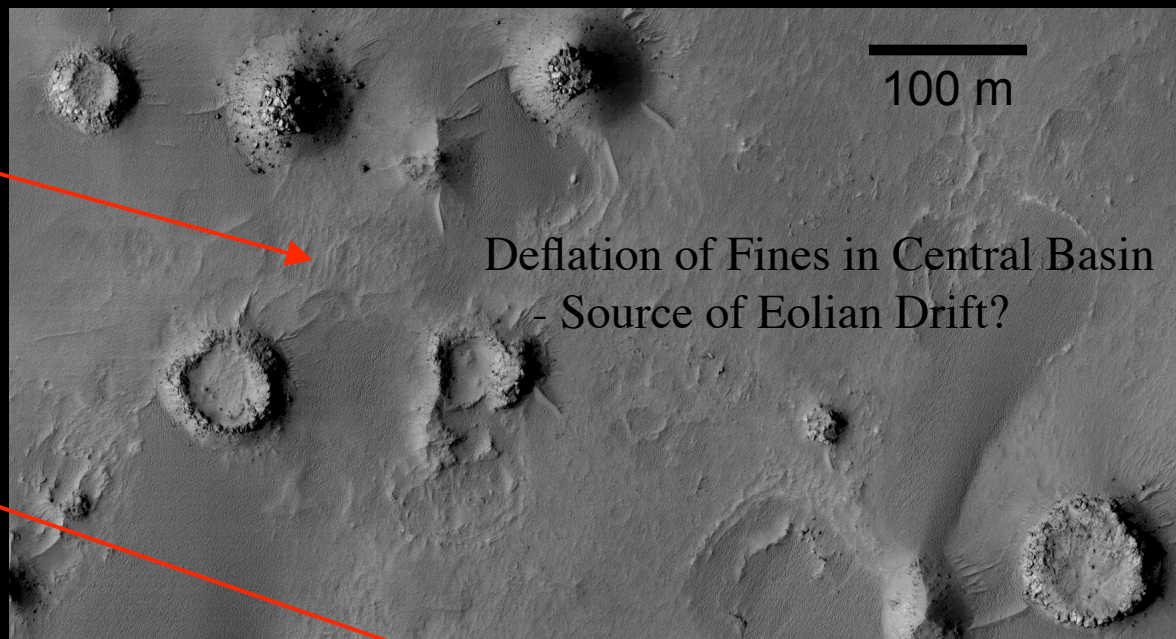
Fine towards
basin center

Distal Alluvial vs. Lacustrine:



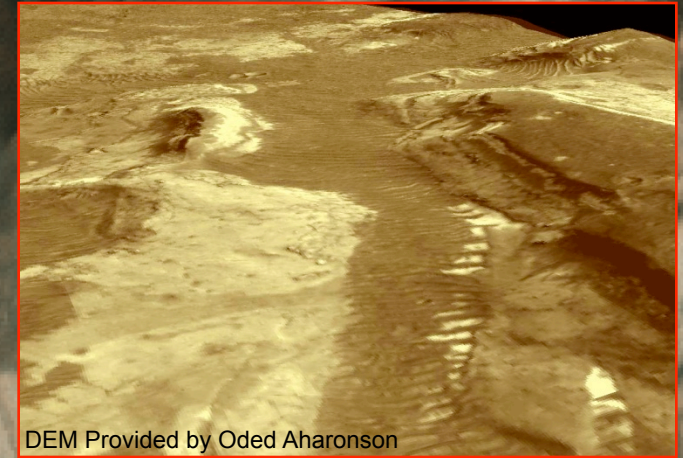
PSP_003433_1540

Central Basin: Layers, Distal Fines, Shorelines?



Origin of Lower Unit Deposits

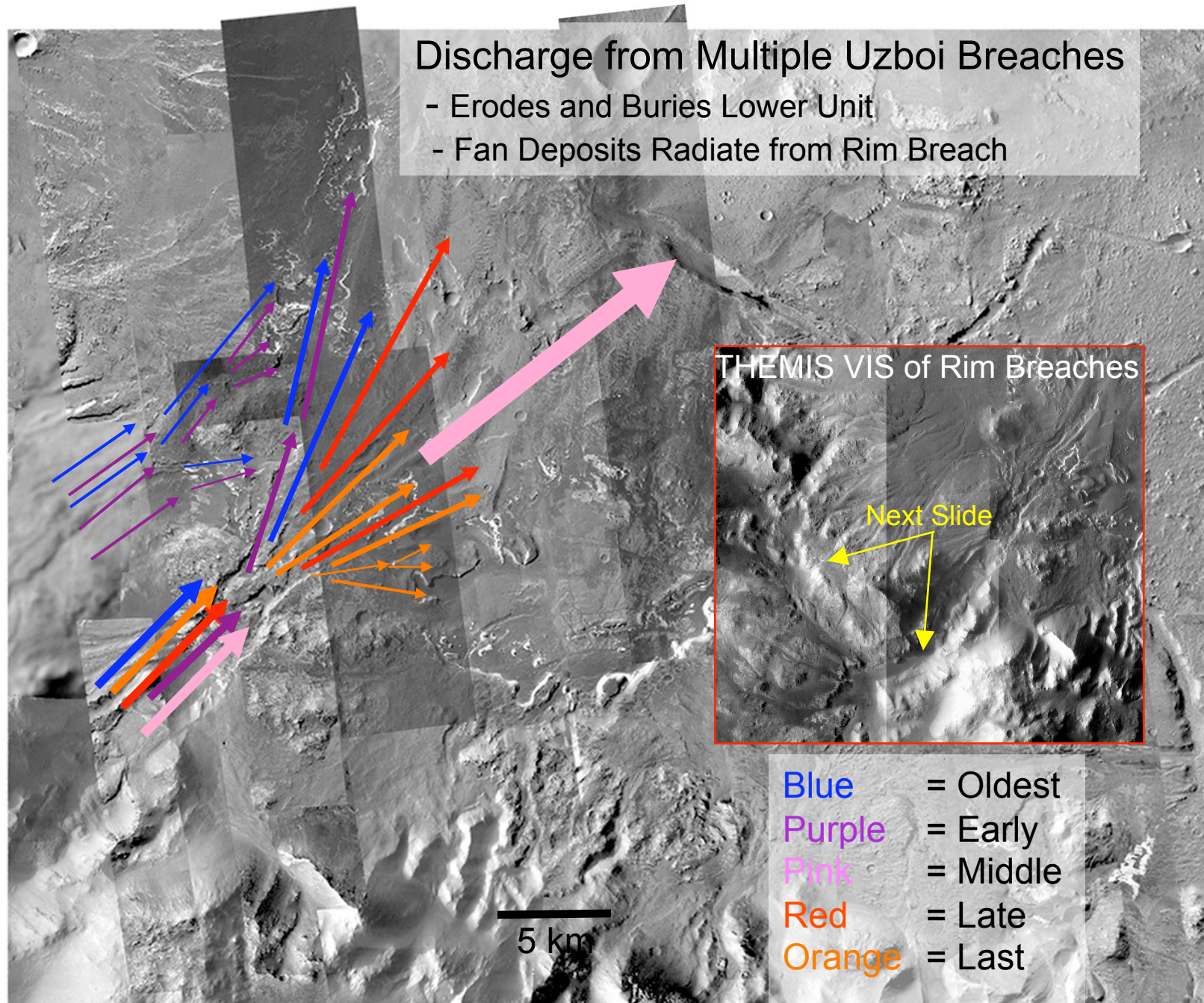
Block is ~85 m long



PSP_001468_1535_RGB

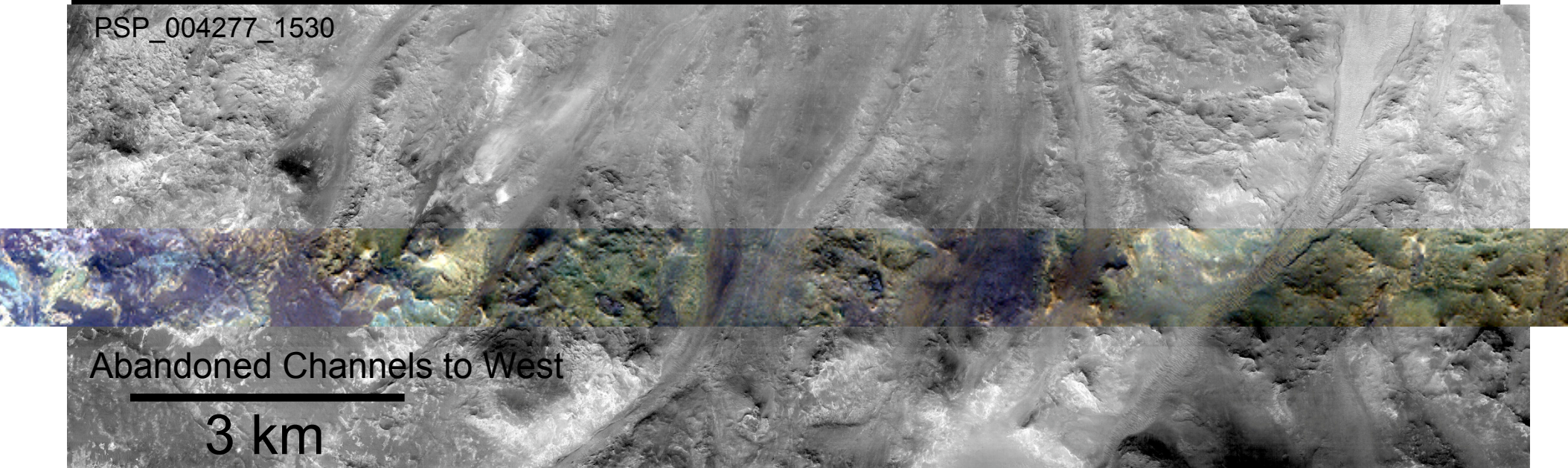
- Layers (Horizontal?) Distinguished to Limit of Image Resolution (in Upper Member)
- Topographically Confined (~1960 m), Traceable for kms, Not Likely Volcanic
- Scale of Bedding May Preclude Origin as Master Eolian Sets
- Elevation Confinement Makes Airfall/Pyroclastic Unlikely
- Sometimes Incorporate Meter-Sized Rocks (Alluvial, Ejecta, Ice-Rafted)
- Phyllosilicates present, In Situ or from Walls (Pre-Holden Deposits/Hydrothermal?)
- First Occurrence of Phyllosilicates in Well Understood Geologic Context
- Distal Alluvial or Lacustrine? Clues from Exposed Fan Fronts, Central Basin?
- Scale and extent of bedding may contrast w/scale of fringing alluvial systems

Origin of the Upper Unit:

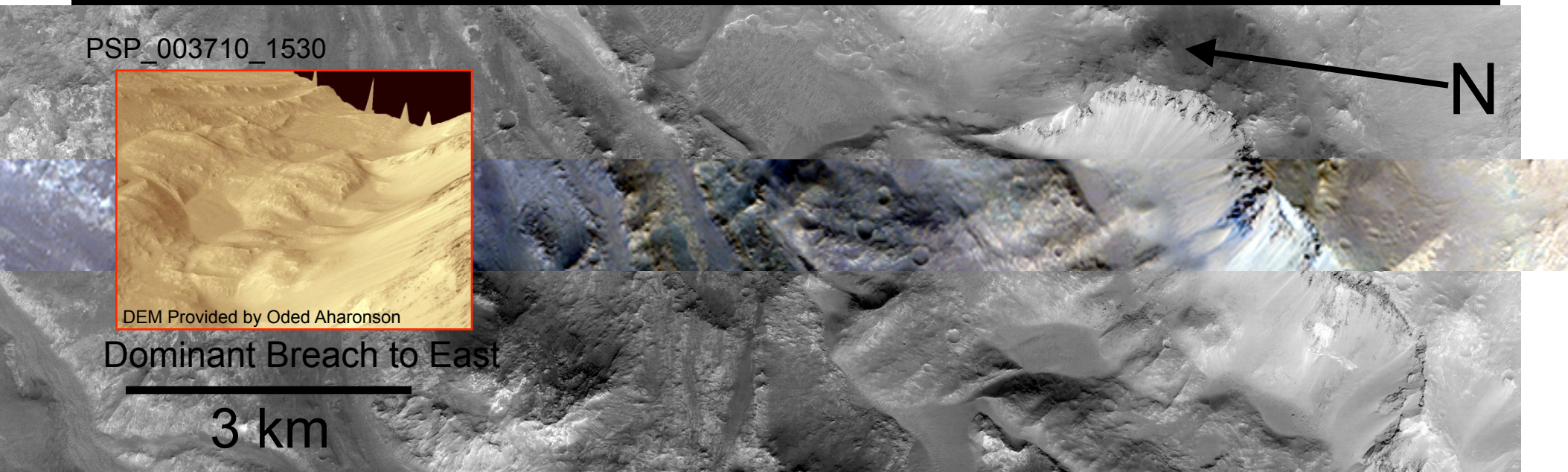


Uzboi Overtops Holden Rim:

PSP_004277_1530



PSP_003710_1530



Upper Unit Deposits

Erode and Unconformably Drape Early Phase Deposits:

- Forms Cliffs
- Retains craters, but buried by eolian ripples
- Displays horizontal/inclined bedding
- Entrain blocks of underlying deposits
- Reaches to Common Level in Basin?
- Benches/Eroded Fans Along Margin

← Flow

PSP_001468_1535

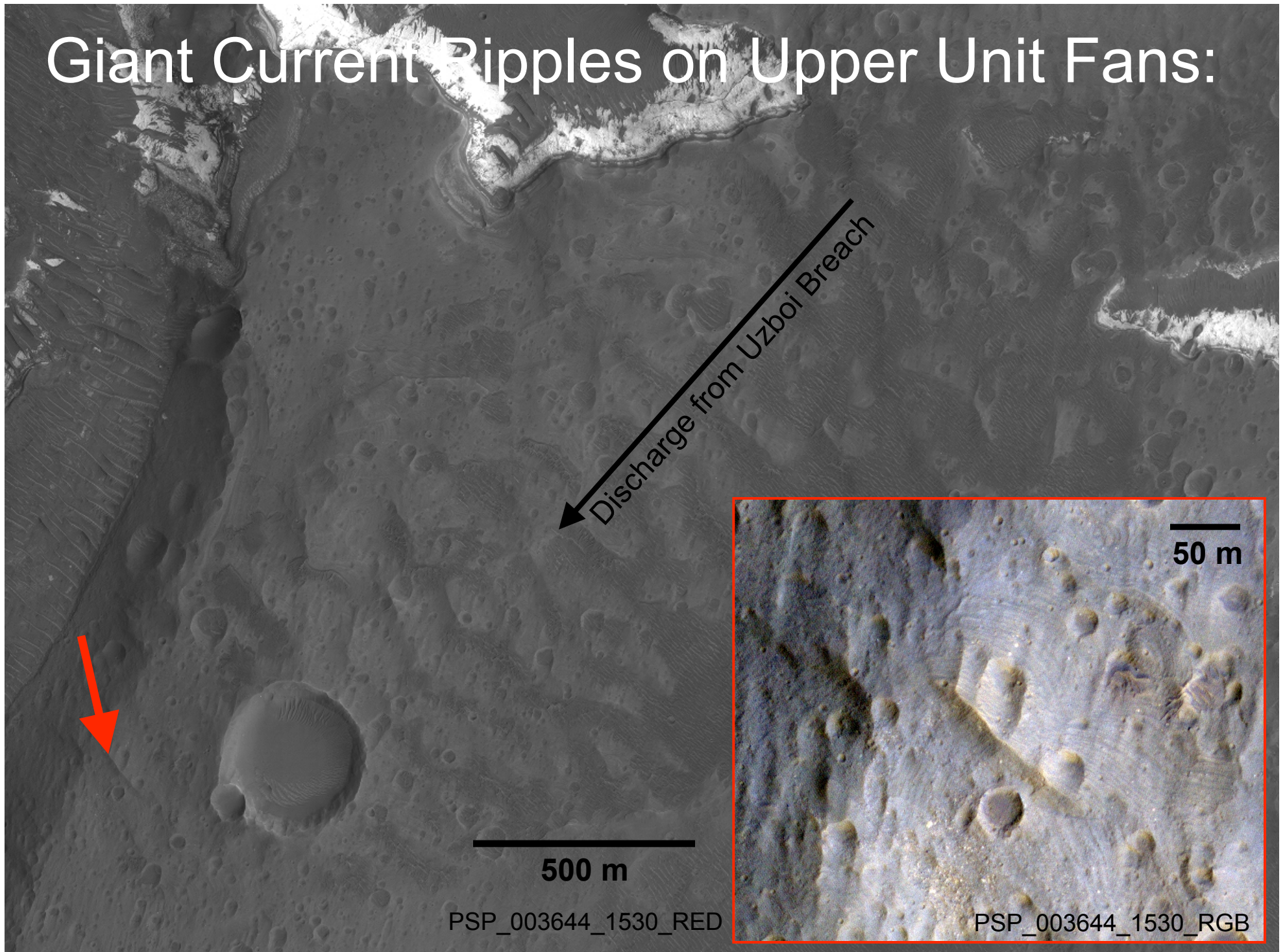
100 m

Upper Unit Deposits Drape Eroded Lower Unit Deposits

TRA_000861_1530_IRB

200 m

Giant Current Ripples on Upper Unit Fans:

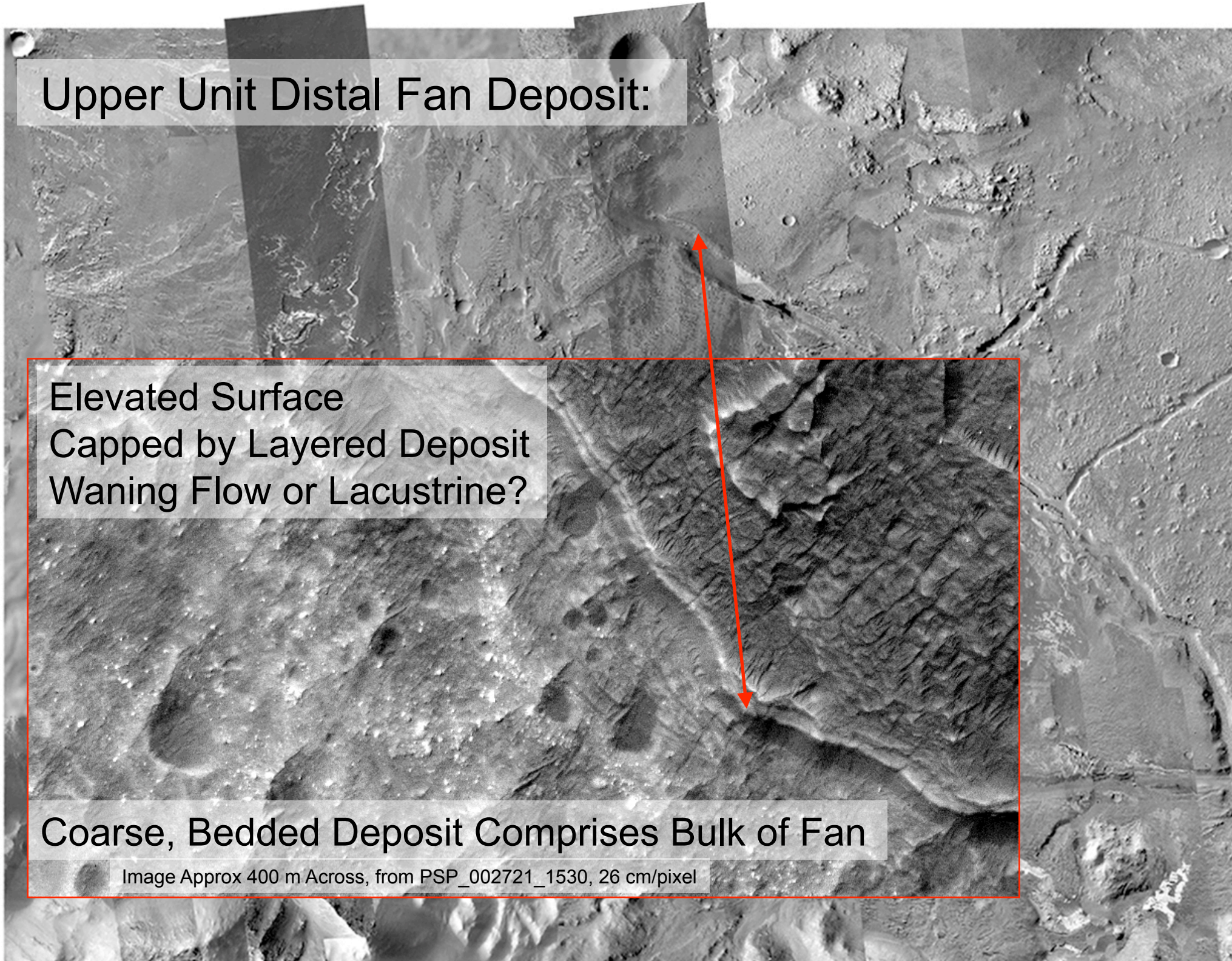


Upper Unit Distal Fan Deposit:

Elevated Surface
Capped by Layered Deposit
Waning Flow or Lacustrine?

Coarse, Bedded Deposit Comprises Bulk of Fan

Image Approx 400 m Across, from PSP_002721_1530, 26 cm/pixel



Upper Unit: High Energy Discharge:

Eroded Blocks of Early Phase Upper Section in Lee of Flow Obstruction

PSP_1468_1535

100 m

Distal

Origin of Upper Unit Deposits:

- Alluvial, Lacustrine, Eolian, or other?
 - Proximal Beds Truncate at Low Angles
 - Grade to Parallel Beds Distally and Upsection
 - No Large Scale Eolian Cross Beds
 - Cuts First Phase Beds and Entrain Large Blocks
 - Similar Composition to Crater Walls (THEMIS and CRISM)?
 - “Bathtub Ring” Indicates Topographic Confinement (-2060 m)
- Alluvial Grading to Lacustrine (Up and Distally)?
 - Consistent with Shifting Source and Volume of Discharge
 - Distal Lacustrine Source of Eolian Drift? (Central Basin Deflation)
 - Composition Implies Little Weathering
 - Short-Lived Wet Late Wet Phase
 - Lake Lasts 100's of Years for Evaporation of ~1 m/yr

parallel layers

Proximal

downlap surface

truncated layers

From Ralph Milliken

Summary: Context, Diversity, Habitable, Quiescent

- Mega Breccia Exposed in Walls
- Lower Unit Alluvial/Lacustrine w/Phyllosilicates
 - Quiescent Depositional Setting
- Short-Lived Upper Unit (Uzboi) Phase Alluvial/Lacustrine
- Both Wet Phases Noachian
- Mark End of Significant Activity (no Glacial)
- Excellent Candidate Landing Site for MSL

